The optical properties of aerosols in Amazonia: from natural biogenic to biomass burning particles

Paulo Artaxo[1], Xuguang Chi[4], Henrique M. J. Barbosa[1], Luciana V. Rizzo[2], Andrea Arana[1], Joel F. Brito[1], Elisa T. Sena[1], Joel Schaefer[3], Meinrat O. Andreae[4].
[1] Institute of Physics, University of São Paulo,
Rua do Matão, Travessa R, 187. CEP 05508-090, São Paulo, S.P., Brazil.
[2] Departamento de Ciências Exatas e da Terra, UNIFESP - Campus Diadema,
Rua Prof. Artur Riedel, 275 , CEP 09972-270, Diadema - São Paulo, Brazil.
[3] NASA Goddard Space Flight Center, Code 618, Bldg. 33, Rm. F541. Greenbelt, MD 20771-0001, USA
[4] Biogeochemistry Department, Max Planck Institute for Chemistry, P.O. Box 3060, 55020 Mainz, Germany.

Keywords: Aerosol particles, Amazonia, biosphere-atmosphere interactions, Biomass Burning,
Presenting author email: Artaxo@if.usp.br

Amazonia is one of the most pristine continental areas in the wet season, with very low aerosol particles concentration. Over the last 20 years, the Large Scale Biosphere Atmosphere Experiment in Amazonia (LBA) has implemented research projects aiming to study aerosol optical properties (Davidson et al., 2012). Three aerosol components are the most visible: 1) The natural biogenic emissions of aerosols; 2) Secondary organic aerosols from biogenic VOCs emissions; and 3) the biomass burning component. Long term monitoring of aerosols and trace gases were performed in two sites: a background site in Central Amazonia, 55 Km North of Manaus (called ZF2 ecological reservation) and a monitoring station in Porto Velho, Rondonia state, a site heavily impacted by biomass burning smoke. Recently, two new sites are providing new information on aerosol optical properties: the so called ATTO (Amazon Tall Tower Observatory) that is a very clean site North of Manaus and the EMBRAPA site, 50 Km NE of Manaus, with the long term operation of a Raman Lidar and other instruments. At these sites, detailed aerosol characterization is being performed, with the measurements of aerosol size distribution from 10 to 600 nm, spectral light absorption measured with Aethalometer and MAAPs, light scattering with the use of TSI and Ecotech 3 lambda nephelometers. In parallel, aerosol composition is being measured for inorganic components (measured using XRF) and organic and elemental carbon determined with a Sunset OC/EC instrument. We are also operating a network of 6 CIMEL sunphotometers from AERONET and the use of MODIS AOD allows to obtain the large scale aerosol distribution. Combination of MODIS and CERES allowed the calculation of top of the atmosphere large scale aerosol radiative forcing.

Aerosol optical depths (AOD) of more than 4 at 550nm was observed frequently over biomass burning areas, while in the wet season, central Amazonia shows very low AOD of about 0.05 to 0.1 at 550 nm. At the ZF2 site, dry particle median scattering coefficients at the wavelength of 550 nm increased from 6.3 Mm^{-1} to 22 Mm^{-1}, whereas absorption at 637 nm increased from 0.5 Mm^{-1} to 2.8 Mm^{-1} from wet to dry season. Angstrom exponents for scattering were lower during the wet season (1.6) in comparison to the dry season (1.9), which is consistent with the shift from fine mode biomass burning aerosols, to biogenic aerosols, predominant in the coarse mode. Single scattering albedo (SSA), calculated at 637 nm, did not show a significant seasonal variation, averaging 0.86±0.08 for dry particles. AERONET SSA at 550 nm for the region shows an average of 0.91±0.04. A detailed analysis of aerosol optical properties was provided in Rizzo et al., 2012.

Combined analysis of MODIS and CERES for a 10 years study shows that the mean direct radiative forcing of aerosols at the top of the atmosphere (TOA) during the biomass burning season was $-5.6\pm1.7 Wm^{-2}$. It was observed that for high AOD (larger than 1 at 550 nm) the maximum daily direct aerosol radiative forcing at the TOA may be as high as $-20 Wm^{-2}$ locally. Details of this analysis can be found in Sena et al., 2012.

At the ATTO site, very low aerosol light scattering and absorption was observed, with a wet season light scattering typical values of 6 Mm-1 at 550 nm, while BC typical values are in the range of 70-100 ng/m³. The average SSA at ATTO is about 0.89, a value slightly higher than observed at the ZF2 site (0.86).

Elemental composition of aerosols shows that sharp increases in Al, Si, Ti and Fe are associated with Sahara dust input into Central Amazonia that is also easily observed with our Raman Lidar.

This work presents a general description of the aerosol optical properties in Amazonia, both during the Amazonian wet and dry seasons.

We would like to thank the INPA LBA central office in Manaus for logistical support for the ZF2 and ATTO sites. This research was funded by the FAPESP Thematic project AEROCLIMA, 2008/58100-2, and CNPq/INCT projects.

Rizzo, L.V., et al, Atmos. Chem. Phys. Discuss., 12, 23333–23401, 2012.
Sena, E. T. et al., Atmospheric Chemistry and Physics, 13, 1261–1275, 2013.
Davidson, E. A. et al., The Amazon Basin in Transition. Nature, 481, 321-328, 2012.